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# Thematic series on service composition for the future internet

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**Abstract**

During the last few years, there has been a growing interest around the development of new ideas envisioning the opportunities of combining Internet and Services. The "Future Internet" (FI) concept has been introduced and it is now central to several initiatives. Specifically, with respect to the Internet of Services, many research communities refer to the well-founded Service-Oriented Computing (SOC) as the reference paradigm for FI computing. SOC promotes the idea of assembling application services into a network of services that can be loosely coupled to create flexible, dynamic business processes and agile software systems, which span organizations and computing platforms. Service composition approaches will certainly have an important role in shaping the SOC within the vision of FI. Despite the great interest in Service Composition, no common foundations and principles have been established yet for the FI of Services. Developing FI applications encompasses a variety of aspects, ranging from modeling and analysis issues in the early phases of their development, to issues related to their implementation and run-time management. This thematic series brings together innovative contributions to the research and development of novel service composition approaches to assist the design, development, validation and execution of service-oriented applications for the FI.

## 1 Introduction

This thematic series of the Journal of Internet Services and Applications (JISA) presents a collection of articles around the topic of Service Composition for the Future Internet. This series comprises papers dealing with novel service composition approaches to assist the design, development, validation and execution of service-oriented applications for the Future Internet (FI) [1].

The FI promotes a distributed computing environment that will be increasingly inhabited by a virtually infinite number of software services. Software systems will be more and more built by composing together software services distributed over the Internet. This calls for new networking paradigms, new service infrastructures and architectures, as well as flexible and dynamic composition mechanisms.

With respect to the Internet of Services, many research communities refer to the well-founded Service-Oriented Computing (SOC) [2] as the reference paradigm for FI computing. SOC promotes the idea of assembling application services into a network of services that can be loosely coupled to create flexible, dynamic business processes and agile software systems, which span organizations and computing platforms.

However, despite significant progress in the SOC paradigm and supporting technologies in the last 10 years, substantial challenges remain, arising from changes in the Internet [3]. Over the years, the Internet has become the most important networking infrastructure, enabling all to create, contribute, share, use, and integrate information and knowledge. As a result, the Internet is changing at a fast pace and is called to evolve into the Future Internet, i.e., a federation of service and self-aware networks that provide built-in and integrated capabilities such as: service support, contextualization, mobility, security, reliability, robustness, and self-management of communication resources and services.

Due to the availability of a large number of existing and ready-to-use software services in the FI, Service Composition (SC) approaches will certainly have an important role in shaping the SOC within the vision of FI. Despite the great interest in Service Composition, no common foundations and principles have been established yet for the FI of services. Developing

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FI applications encompasses a variety of aspects, ranging from modeling and analysis issues in the early phases of their development, to issues related to their implementation and run-time management, their development in multi-organization and multi-domain scenarios towards enabling Business-to-Business (B2B) collaboration. This also includes aspects related to the definition of techniques and tools to support self-adaptive composition, and distributed coordination/mediation of software services.

To this end, this thematic series includes papers where researchers have addressed issues related to the specification of cross-organizational and cross-domain service collaborations [4] and their development [5]; self-adaptive service compositions [6] and their management [7]; and heterogeneous services interoperability in the FI through automated protocol mediation [8].

## 2 The papers

The set of papers accepted for this thematic series covers different research topics in the service composition area, such as B2B collaboration and interoperability in support of cross-organization and cross-domain FI applications, as well as on-the-fly and self-* composition approaches to the development of adaptive composite FI applications. The content of each paper is summarized below.

Norta et al. [4], in their paper "**eContractual choreography-language properties towards cross-organizational business collaboration**", answer the following research question: how to systematically develop a language for cross-organizational and contract-based collaboration specifications? The objective is to understand why existing choreography languages and other XML-based languages for SOC lack adoption by industry. One of the main reasons is that current approaches to language development do not take into account sociotechnical suitability and expressiveness deficiencies recognizing the interaction between people in organizations and technology in workplaces. This paper presents an eSourcing ontology that describes the ontological concepts and properties of smart contracting, which is an essential ingredient for the management of decentralized autonomous organizations.

When facing automatic service composition in markets of composed services for end users, Jungmann et al. [6], in the paper "**An approach towards adaptive service composition in markets of composed services**", focus on the functional discrepancy between what a user wants specified in terms of a request and what a user gets when executing a composed service. A learning recommendation system is proposed. The system expands the capabilities of existing composition algorithms to facilitate adaptivity and consequently reduces functional discrepancy. The learning recommendation system supports a symbolic approach in decision-making, and reinforcement learning techniques enable the recommendation system to adjust its recommendation strategy over time based on user ratings. A prototypical composition framework has been implemented, and promising results from experiments conducted in the image processing domain are reported in the paper.

Aubonnet et al. [7], in the paper "**Management of service composition based on self-controlled components**", introduce an entity of service composition called the Self-Controlled Component (SCC), including functional and non-functional specifications. SCCs benefit both from the strong structure, explicit composition, and autonomic management of component-oriented programming, from the highly dynamic composition, and from the discovery capacities of service-oriented computing. Self-control mechanisms are then attached automatically to SCCs to enable autonomic application management during execution. The objective is to provide strong Quality of Service (QoS) guarantees of composed applications. Then, the concept of Virtual Private Service Network (VPSN) and Virtual Service Community (VSC) is proposed to model the personalised Service Level Agreement (SLA) where user requirements and provider offers converge on a QoS contract.

In the paper "**SDG-Pro: a programming framework for software-defined IoT cloud gateways**", Nastic et al. [5] address the development of novel cross-organization and cross-domain applications in the emerging IoT cloud domain, as well as optimizing existing business processes. In their paper, Nastic et al. introduce SDG-Pro – a novel programming framework for software-defined IoT cloud systems. The main features of the proposed framework include programming abstractions, as well as governance APIs that allow for programmatic management of software-defined gateways throughout their entire lifecycle. The SDG-Pro framework enables easier, efficient and more intuitive development of IoT cloud applications. It promotes the everything-as-code paradigm for IoT cloud applications in order to provide a uniform, programmatic view on the entire development process. The ability of the framework to support development of IoT cloud applications is illustrated, and a real-world case study on managing fleets of electric vehicles is evaluated.

Bennaceur et al. [8], in the paper "**A unifying perspective on protocol mediation: interoperability in the future internet**", address the dynamism and the heterogeneity of software systems composing the FI, and recognize the need of approaches supporting the interoperability between software components in the FI - without modifying them. In this paper the authors propose a unified approach for achieving interoperability

between heterogeneous software components with compatible functionalities across the application and middleware layers. First, a solution is provided to automatically generate cross-layer parsers and composers that abstract network messages into a uniform representation independent of the middleware used. Second, the generated parsers and composers are integrated within a mediation framework to support the deployment of the mediators synthesised at the application layer. The overall goal is to reconcile the differences between software components from the application down to the middleware layers. A case study in the area of conference management is used to evaluate the proposed approach.

## 3 Papers selection

There were two independent cycles of submissions and the papers were published as soon as they became ready. Each manuscript went through several revisions before the final acceptance. We invited a number of leading experts in the area to form an editorial committee to thoroughly review the papers. All manuscripts were reviewed by at least three members of the editorial committee. For each review cycle, guest editors checked the new version of the papers produced after the review to establish whether the authors carefully and adequately addressed the reviewers' comments. When the reviewers' comments were not completely addressed, a further cycle of review was required. Thus, for each peer-reviewed paper, the final decision was always confirmed by the guest editors. The papers were reviewed by a total of 16 reviewers. The names of the editorial committee members are listed on the acknowledgements of this editorial.

## 4 Conclusion

Working on this special issue we confirmed that the FI of services is becoming a reality with a plethora of services, including thing-based services, bound to rapidly evolve. Providing design and development support to build innovative FI applications, while dealing with the availability of a virtually infinite number of software services, requires a rethinking of service composition methods and related SOC technologies devised for today's Internet. Thus, accounting for the overall service-oriented interaction pattern underlying the SOC paradigm, future research directions should address crosscutting concerns on FI services description, discovery, access, and composition:

- *description* – investigate the trade-off between rich service descriptions and related processing complexity, from purely syntactic descriptions to semantic ones;
- *discovery* – investigate service discovery protocols for the ultra large scale FI that, while bridging the heterogeneity of existing protocols, control the quality of the retrieved information and provide security, privacy, and trust guarantees;
- *access* – exploit novel access solutions that, despite the heterogeneity and mobility of the FI, enable highly-dynamic bindings while guaranteeing an acceptable quality of service;
- *composition* – face issues related to multi-organization and multi-domain service access still guaranteeing the required security, privacy and trust; in addition, novel composition approaches must support a transparent reuse of existing services, and be as much as possible automatized so as to handle the complexity of the composition code synthesis, while guaranteeing correctness by construction.

**Competing interests**
The authors declare that they have no competing interests.

**Author's contributions**
All authors read and approved the final manuscript.

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